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COST SHARING, PRICE SUPPORTS, AND TAXES: WHAT IT TAKES TO MAKE NO TILLAGE COMPETITIVE IN THE LONG RUN

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INTRODUCTION

A survey in October and November of 1979 by Lewis Harris and Associates found that 71 percent of the American public thought that soil conservation programs which were voluntarily undertaken by farmers, and that were accompanied by low-interest loans and other financial incentives, were equitable to both farmers and nonfarmers (Harris). This is how most current federal soil conservation programs are administered. These types of soil conservation programs fall under the Soil and Water Resources Conservation Act (RCA) category of "Redirecting Present Conservation Programs" (USDA, p. 32). The redirection would entail the modification of these 34 existing conservation programs to achieve conservation goals through changes in their cost sharing, education, technical assistance, grant, and loan provisions. Participation in these redirected programs would be voluntary. Some reseachers believe that they will be the major thrust of soil conservation policy for some time to come (Bouwes and Lovejoy; Moore, et al.).

On the other hand, there is much discussion in the literature concerning alternatives to a voluntary approach to soil erosion control. The sentiment of many was summarized by Walker and Timmons (p. 12) who stated that "while progress has been made during the 44 years subsidies have been employed, soil loss exceeded five tons per acre on 97 million acres in 1977, and sedimentation in streams still exceeds clean water objectives." Similar views were expressed by Libby (p. 156) when he wrote "I believe the days of completely voluntary conservation programs are numbered, if not over." The RCA labels one alternative to the voluntary approach as cross-compliance. Cross-compliance programs would require farmers to employ some specified soil conservation method or methods in

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order to be eligible for USDA commodity price support programs, low-interest loans, and cost share programs (USDA, p. 32). Cross-compliance programs are advanced by Libby; Benbrook; and Dinehart and Libby among others. This approach seems to be gaining acceptance in both the scientific and popular press. The RCA indicates that the cost of complying could either be solely borne by the farmer or there could be some governmental technical and financial assistance (USDA, p. 32).

Another approach in the RCA summary which is receiving considerable attention is that of direct regulation (USDA, pp. 32-33). The RCA's recommendation is that any soil conservation regulations be gradually phased in, and that they be accompanied by strong assistance programs. It is also suggested that a farmer who fails to comply with the regulations could be taxed, fined, and/or required to reimburse the government for any assistance it had provided the non-complying farmer (USDA, p. 34). Regulatory policies have been evaluated by Harder, Daniel, and Madison; Walker and Timmons; and Libby.

The objectives of this paper are: (1) To briefly present the yield projection models we employed for the long-run analysis of soil conservation policies, (2) to briefly describe the setting of the study and the data employed, (3) to develop one policy from each of the three categories introduced above to be used in the long-run analysis, (4) to present a generalized formula for a break even analysis which can be solved to determine the level of a policy necessary to equate the summed discounted net income of heavy and no tillage for different discount rates and planning horizons, and (5) to present and discuss the empirical results of the policies outlined in (3) examined with the analysis framework discussed in (1), (2) and (4).

YIELD PROJECTION MODELS

The empirically estimated yield projection models for the two crops used in this analysis (with the w, p, s and k subscripts standing for wheat, peas, a crop index and a tillage system index respectively) are:

(1) $Y_{w,k,t} = [38.92 + 40.50(1 - 0.9^{(D_0 - (A_k)t)})]\mathcal{E}_{w,k}e^{(0.0100(t + 6))}$, for winter wheat and:

(2) $Y_{p,k,t} = [636.58 + 711.32(1 - 0.7^{(D_0 - (A_k)t)})]\mathcal{E}_{p,k}e^{(0.0098(t + 5))}$, for dry peas, where: $Y_{s,k,t}$, yield for crop s in year t, for tillage system k, with yield for winter wheat projected in bushels per acre and for dry peas in pounds per acre; D_0 is the initial topsoil depth in inches; A_k is average annual soil loss in inches, predicted by the Universal Soil Loss Equation (Wischmeier and Smith, McCool et al.); $\mathcal{E}_{s,k}$ is the tillage-yield effect for crop s and tillage system k ($\mathcal{E}_{s,k} = 1.00$ for conventional tillage, $0 < \mathcal{E}_{s,k} \leq 1.00$ for conservation tillage); t is a yearly time index with t = 0, 1, 2, ..., n, with 1980 = 0 (6 and 5 years are added to t in the exponential growth terms of equations (1) and (2), respectively, to correct for the fact that the data used to estimate the yield-topsoil response functions were collected in time eras ending in 1974 and 1975, respectively); e is the exponential operator (See Taylor for details on estimation and data sources). An important characteristic of these equations is that they incorporate the yield depressing impacts of topsoil erosion (portion of equation enclosed by the "[]" brackets), the yield boosting effects of technological progress (the exponential portion of the equations), and any direct tillage effect on yield (the $\mathcal{E}_{s,k}$ term). Improved agricultural technology is assumed to shift both the wheat and pea yield response functions upward at the rate of about one percent per year. As a result of the multiplicative technology shift, the deeper the topsoil, the greater is the absolute impact of technical progress. Taylor and Young provide additional detail on the properties of, and the justification for the specification of, the yield projection model. The yield penalty of conservation tillage systems, represented by the tillage-yield effect $\mathcal{E}_{s,k}$, is due to weed control, disease, and seed germination problems encountered with conservation tillage in the Palouse (Harder, Peterson, and Dowding; Harder).

STUDY LOCATION AND DATA

The study area is the 700,000 acre Palouse annual cropping area located in southeastern Washington and adjacent areas in Idaho. The rolling hills of this area are subject to some of the highest rates of soil erosion in the nation (Kaiser). On these steep hillsides reduction in tillage intensity is the most economically promising erosion control practice (USDA, SCS, FS, ESCS). Changes in crop yields and farm profits (if any) associated with changes in tillage systems are a long term phenomenon. A static analysis would fail to reflect the true long term costs or benefits of such a change which is why we used a long run model in this analysis.

An 1,100 acre farm on average Palouse topography with 550 acres each in winter wheat and dry peas was constructed (see Taylor for more detail). A heavy tillage system (moldboard plow wheat stubble, disc pea stubble) and a no tillage system (drill seed directly into stubble of preceding crop) were examined. The tillage yield effect ($E_{s,k}$ of equations (1) and (2)) of heavy tillage was 1.0 for both crops, but was 0.873 for wheat and 0.863 for peas grown with no tillage based on the best (although preliminary) experimental evidence on yield effects of continuous no tillage systems in the Palouse (Harder; Harder, Peterson, and Dowding).

Five year weighted average prices of $3.66 per bushel for winter wheat and $10.50 per hundredweight for dry peas were employed. All other costs and income computations were in 1980 dollars. Net income was calculated as returns to land, and owner-operator labor and management. The average variable costs of heavy tillage per acre of rotation were $110.34 while they were $122.50 per acre for no tillage, the difference being primarily due to no tillage's increased fertilizer and herbicide requirements. On the other hand, due to a smaller equipment complement, the per acre fixed costs of no tillage were $49.27 compared to $52.04 for heavy tillage. Reduced tillage implement requirements for no till were largely offset by the need to purchase a no till drill, a relatively costly implement.

The slight fixed cost advantage of no tillage was offset by its higher variable costs which caused the total costs of no tillage to be \$9.39 per acre more than those of heavy tillage (Taylor).

In a 1980 survey of eastern Palouse farmers, 60 percent (of 178) used moldboard plowing for their first operation after wheat harvest while 33 percent of these farmers disced the pea residue as their first step in planting wheat (STEEP project). The heavy tillage system can therefore be considered as a conventional eastern Palouse tillage system. The overall average erosion rate of the heavy tillage system was 0.10294 inches per year, while it was only 0.02422 inches per year for the no tillage system (McCool).

EROSION CONTROL POLICIES

The implicit conservation program objective for which the policies of this study were developed was to make no tillage rather than heavy tillage the conventional tillage system in the Palouse. To accomplish this goal, policies were analyzed with a breakeven analysis to determine policy levels which would make the summed net present value (SNPV) of farm income of no tillage equal to that of heavy tillage.

The first policy was from the RCA category of redirecting present conservation programs. It consisted of a cost sharing program to subsidize no tillage farmers for the cost differential between heavy and no tillage. The next policy consisted of a cross-compliance price support program for farmers adopting no tillage. In contrast to the two preceding policies which attempted to make no tillage more attractive to farmers, the third policy tried to make heavy tillage less attractive to farmers. Farmers were fined for using heavy tillage.

BREAKEVEN ANALYSIS FORMULA

The following equation presents the generalized per acre breakeven formulation used in this study:

$$(3) \quad \sum_{t=1}^{n} \frac{(.5)P_w Y_{w,h,t} + (.5)P_p Y_{p,h,t} - C_h - T}{(1 + r)^t} = \sum_{t=1}^{n} \frac{(.5)SP_w Y_{w,n,t} + (.5)SP_p Y_{p,n,t} - C_n(1-L)}{(1 + r)^t}$$

where: the h and n subscripts stand for heavy tillage and no tillage respectively; C_k is the cost per acre of wheat-pea rotation using the k^{th} tillage system; r is the real discount rate; P_s is the crop price of crop s; T is the per acre soil erosion tax on heavy tillage; S is the no tillage price support variable $(1.00 \leq S)$; L is the no tillage cost sharing variable $(0 \leq L \leq 1)$; and n is the length of planning horizon in years. To determine the level of any of the three policies necessary to equate the income of the two tillage systems for a given discount rate and planning horizon, one need only solve equation (3) algebraically for that parameter since all the other parameters would be given. This solution procedure was conducted for 1980 (D_0) topsoil depths of 6 and 18 inches with planning horizons of 1, 5, 10, 20, and 50 years and real discount rates of 0, 1, 3, 5, and 10 percent.

Figures 1 and 2, which plot the projected 50-year net income streams without government policies for both heavy and no-till, will facilitate interpretation of the results below. These projections are based on equations (1) and (2) and the output price and production cost levels specified above. Due to the one percent annual upward shift in the yield-topsoil depth functions caused by general agricultural technical progress, net returns to land, operator labor, and management grow over the entire 50-year period for all but one scenario (heavy till on 6 inch initial topsoil). Due to the nonlinearity of the yield-topsoil depth functions, the more rapid soil loss with heavy tillage imposes a much greater brake on yield and income growth on the 6 inch than on the 18 inch topsoil. On the deeper topsoil the interaction of the technical progress and yield penalty factor outweigh the relatively modest yield reduction from greater erosion so heavy till continues to increase its yield advantage over no-till throughout the 50 years.

Lacking an unarbitrary basis for forecasting future changes in relative prices, we assumed real output prices and real production costs (net of land, operator labor, and management costs) remained at their 1980 levels throughout the analysis period. However,

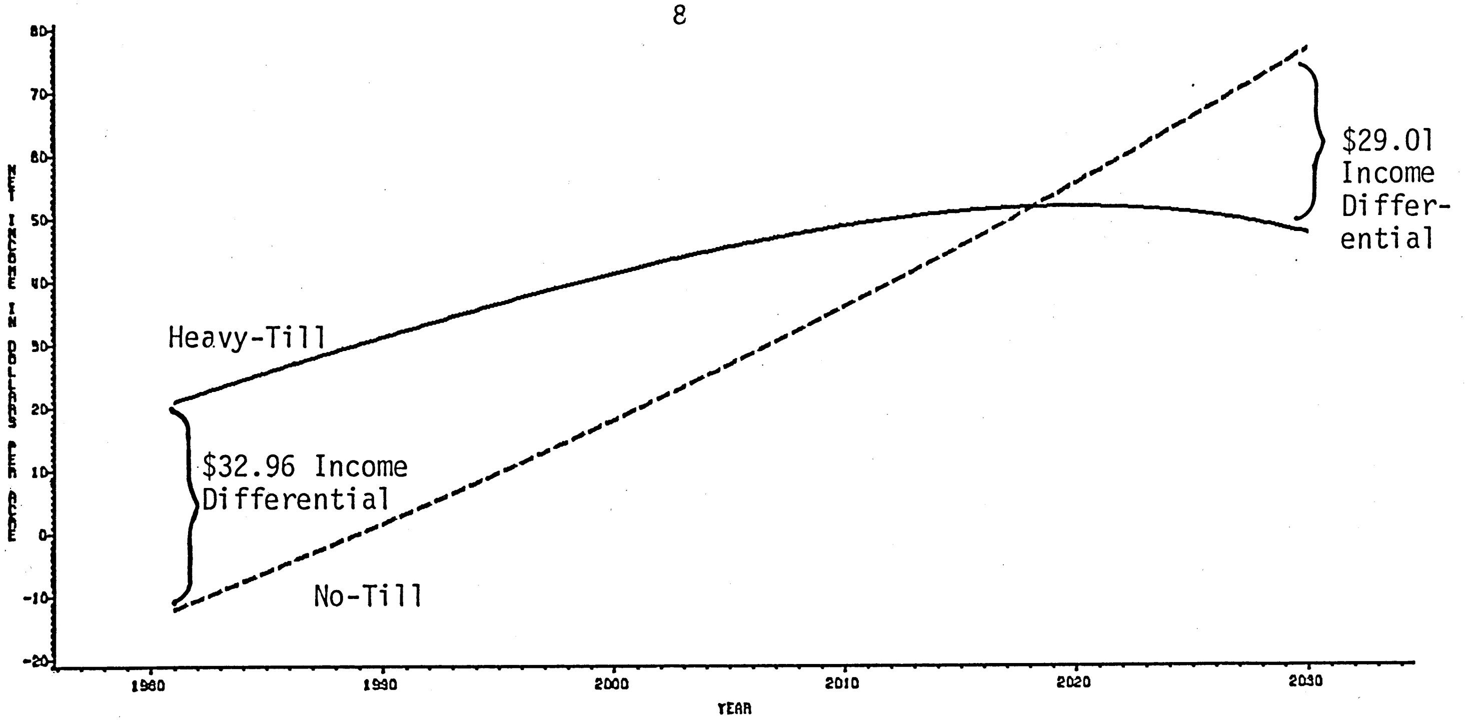

Figure 1. Comparison of No–Till and Heavy–Till Net Income Streams Assuming Initial Topsoil Depth of 6 Inches and No Government Policies.

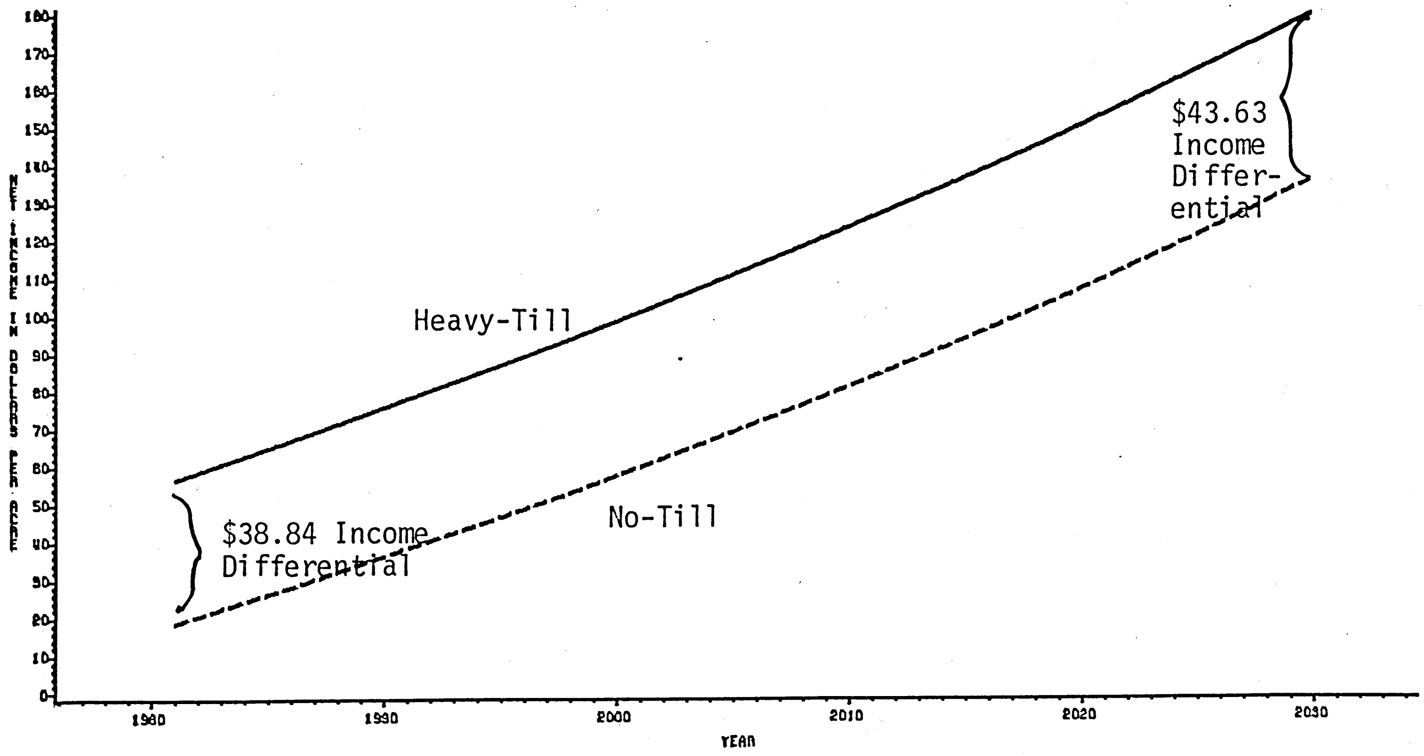

Figure 2. Comparison of No–Till and Heavy–Till Net Income Streams Assuming Initial Topsoil Depth of 18 Inches and No Government Policies.

if net returns to land, operator labor and management indeed continue to grow as projected, it is likely that increased rents to land, manifested by land value appreciation, would be the primary beneficiary of such technical progress in the future as in the past. Of course, it is also possible that rising relative costs of other production inputs could absorb some of these returns.

Comparing the net income levels in Figure 1 and 2 reveals that farming deep topsoils in the Palouse is a considerably more profitable proposition than farming shallow topsoils. However, each farm generally has widely varying topsoil depths on different topographic aspects within relatively small contiguous areas. Consequently, for reasons of managerial convenience, all land is generally farmed the same way even though farmers recognize that yields (and profits) are lower on shallow soil ridgetops and steep faces.

RESULTS

It should be emphasized that this analysis considers only the on farm impacts of the policies. Administrative costs, off farm costs and benefits are not considered in this presentation.

The results of the cost sharing breakeven analysis are presented in Table 1. With the 6 inch starting topsoil depth, the higher the discount rate, the higher the percentage of no tillage costs which must be shared in order to equate no till income with that from heavy tillage. The high discount rates fail to give much weight to the future improvement in no tillage yields and profits relative to those of heavy tillage (see Figure 1). With 6 inches of topsoil, the longer the planning horizon, the smaller the subsidy must be because a longer planning horizon captures more of the future yield and profit benefits of no tillage. With the initial topsoil depth of 18 inches, however, the results exhibit opposite trends to those for the shallower topsoil. The lower the discount rate and the longer the planning horizon, the greater the percentage cost share must be. This is because, as illustrated in Figure 2, the profitability disadvantage of no till continues to grow throughout the study period. Shorter time horizons and higher discount rates give less weight to this growing profit disadvantage, permitting slightly lower subsidies.

Table 1. Percentage of No Tillage Costs Which Must be Subsidized to Equate No-Till's SNPV of Income to that of Heavy Tillage.

Planning Horizon (Years)	Real Discount Rate (Percent) 0	1	3	5	10
6 inches of topsoil in 1980					
1	19.45	19.45	19.45	19.45	19.45
5	19.10	19.10	19.11	19.11	19.13
10	18.56	18.58	18.61	18.65	18.72
20	17.11	17.21	17.39	17.57	17.95
50	7.68	9.08	11.56	13.54	16.47
18 inches of topsoil in 1980					
1	22.44	22.44	22.44	22.44	22.44
5	22.65	22.65	22.64	22.64	22.63
10	22.92	22.91	22.89	22.87	22.83
20	23.42	23.39	23.32	23.26	23.12
50	24.66	24.50	24.18	23.90	23.40

The results of the cross compliance price support breakeven computations are presented in Table 2. As expected, the required price support steadily diminishes for the 6 inch topsoil scenario as the planning horizon lengthens to capture an increasing portion of the long run profit benefits (or reduced losses) of the soil conserving no-tillage system. Somewhat surprisingly, the required price support also declines with the length of the planning horizon on the 18 inch topsoil. However, this result is explained by the fact that the price support is applied to the gross revenue component of the net return equation, which is growing through time due to yield growth. The cost share, on the other hand, was applied to a cost component which does not grow through time. As the planning horizon lengthens to capture more of this growing gross revenue base, the required percentage price support falls slightly. Higher discount rates give less weight to the growing future gross revenue component of no-till through time so higher percentage support prices are required at higher discount rates for both topsoil depths.

Table 2. Percentage No Tillage Crop Prices Must Be Increased to Equate No-Till's SNPV of Income to that of Heavy Tillage.

Planning Horizon (Years)	Real Discount Rate (Percent)				
	0	1	3	5	10
6 inches of topsoil in 1980					
1	20.95	20.95	20.95	20.95	20.95
5	20.19	20.20	20.21	20.23	20.26
10	19.18	19.21	19.27	19.34	19.48
20	16.87	17.02	17.30	17.58	18.20
50	6.56	7.90	10.43	12.60	16.19
18 inches of topsoil in 1980					
1	20.31	20.31	20.31	20.31	20.31
5	20.10	20.10	20.11	20.11	20.12
10	19.84	19.84	19.86	19.88	19.92
20	19.28	19.31	19.38	19.45	19.60
50	17.36	17.60	18.06	18.47	19.19

The results of the tax policy in Table 3 further emphasize the difference between yield and profit projections on the two topsoil depths.

Table 3. Tax ($/Acre) on Heavy Tillage Necessary to Equate its Income with that of No Tillage.

Planning Horizon (Years)	Real Discount Rate (Percent)				
	0	1	3	5	10
6 inches of topsoil in 1980					
1	33.40	33.40	33.40	33.40	33.40
5	32.80	32.80	32.82	32.83	32.86
10	31.88	31.91	31.97	32.03	32.16
20	29.39	29.55	29.87	30.17	30.84
50	13.20	15.60	19.86	23.25	28.28
18 inches of topsoil in 1980					
1	38.54	38.54	38.54	38.54	38.54
5	38.91	38.90	38.90	38.89	38.87
10	39.36	39.35	39.32	39.29	39.22
20	40.24	40.18	40.06	39.96	39.71
30	42.36	42.08	41.53	41.05	40.19

The necessary tax on heavy tillage decreases with a longer planning horizon with 6 inches of topsoil and increases on the deeper topsoil analogously to the cost share policy of Table 1. With the 18 inch topsoil depth in 1980, the tax decreases with increasing discount rates which is also an analog of the results in Table 1. With higher yields and profits, and a larger yield differential through time on the deeper topsoil ($E_{s,k}$), larger taxes must be applied to heavy tillage to equate the incomes of the two tillage systems on the deeper topsoil.

To help put these policies in perspective, the results with a 50 year planning horizon and a zero percent discount rate on a 6 inch topsoil depth will be briefly examined. For the cost sharing policy, these conditions would require an annual subsidy of $13.19 per acre. For 50 years, for the entire Palouse region, the cost of this policy would be $9,234,355.20. The supported wheat price necessary to equate incomes would be $3.8979 per bushel and the dry pea support price would be $12.24750 per hundredweight. This $0.23790 increase in price for 50 years for the entire 700,000 acres of the Palouse for each bushel of wheat grown would be a substantial cost, as would a $0.74750 per hundredweight price increase for peas. Finally, with a 6 inch starting topsoil, the tax policy would remove $9,240,000 in undiscounted income in 50 years from the Palouse. This would occur whether heavy tillage farmers were taxed this amount, or they were forced to adopt no tillage. With a deeper topsoil depth, the costs of these policies would be even greater.

CONCLUSIONS

The 50 year costs of these programs are substantial. The costs of the first two would be borne by society while the burden of the third would fall on Palouse farmers. This analysis demonstrates that unless these policies are continued indefinitely (50 years or more), farmers would have an incentive to switch back to heavy tillage as soon as the policy were discontinued if, with a given topsoil depth, at any point in time, heavy tillage continues to produce superior incomes. It must also be remembered that these policies equate the incomes of the two tillage systems. It is possible that higher incentives would be required to guarantee the adoption of no tillage.

The authors feel that a viable solution to the problem rests with a reduction in the yield and cost penalties of no-till systems. Research should be heavily directed towards developing no tillage farming systems with reduced yield penalties and lower costs. This is the only way to reduce the income incentive farmers would have to switch back to heavy tillage. We suspect that this research approach would be politically more acceptable than a perpetual subsidy and/or a price support approach. A research program, by itself, is not without risk. If the research fails to develop an economically viable no tillage system, then the long term inherent productivity of the soil may be seriously impaired. Consequently a joint program of intensive no tillage research (for the long term solution) coupled with soil erosion control incentives in the current period (a short run solution) merits consideration.

Other studies indicate that both experimental and perceived yield (and hence profit) reduction are much lower for minimum than for no tillage in the eastern Palouse region (Hoag and Young). Some minimum tillage systems can also cause erosion close to no till levels (McCool). Consequently, both policy incentives and research programs should continue to focus on minimum tillage as well as no tillage systems to solve the serious soil erosion problem in the Palouse.

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